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The Cryosphere
Discussions
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Interactive comment on "Variability in individual particle structure and mixing states between the glacier snowpack and atmosphere interface in the northeast Tibetan Plateau" *by* Zhiwen Dong et al.

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Response to Anonymous Referee #1

General statement: This is an interesting study suitable for publication in TC. There are some important revisions required, but they should be easy for the authors to make.

Major comment: The large radiative forcing shown in Figure 11 (and cited in the abstract) is caused by the huge amounts of impurities in these glaciers. The authors need to point out that these glaciers are much more polluted than is normal for Tibetan glaciers. Line 120 gives the average value of BC (for 10 glaciers) as 854 ppm, or

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854,000 ppb, i.e. about a factor of 40,000 larger than the amounts reported for Tibetan glaciers by Ming et al 2008 (ACP 8, 1343-1352). Some discussion is required before we can believe the results of this paper. I am also surprised that [BC] is∼10 x [MD]. Previous reports find more MD than BC in Tibet.

Author response: Thank you. We have checked carefully here about the amount of BC and others, and we are sorry as it is a mistake by writing the wrong unit here. The unit should actually be ppb (μg /kg) for BC and OC, not ppm; for dust the unit is ppm (μg/g), as the average value of LAPs in the NTP region is derived from previous study (Zhang et al., 2017, 2018; Yan et al., 2016; and also Wang et al., 2013) for the snowpack. Thus the BC level is not that high.

We also checked carefully the result of the calculation using the model to calculate the albedo change based on the above data (see revised Figure 11). Moreover, we have checked throughout the paper, and we think the BC/dust level is still comparable to Ming et al. (2008, ACP) as their previous work result is derived from ice core, with relatively much higher average elevation in Everest (its deposition site with elevation 6500 m compared to 2900∼4750 m a.s.l. of northeast Tibetan Plateau glacier sampling sites in this work) and lower atmospheric BC concentration. Besides, in this work we mainly focused on LAPs (BC, OC, mineral and others) in the glaciers and snowpacks for the surface distributed impurities, which is often accumulated in summer with surface melting and with higher BC concentration, and is thus actually different to that of ice core deposition record, but usually with higher mass level. (See Line 175-183 in the revision).

Besides, we need to clarify that the dust level is actually higher than that of BC in this work; here it is also caused by unit mistake, as the dust unit is μg /g, while the BC and OC unit here is μg/kg. The dust mass level we used here is actually much higher than BC (>10 times). Please also check that in the previous study in Table 2 of Zhang et al., 2018, TC.

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Also see Figure 3 in this work, dust has a similar number concentration with BC in NTP region; however, dust is often larger particle and BC is often fine particles (often in PM2.5 and sub-micro section, Dong et al., 2016AE; Li et al., 2014 JGR), considering together the density of dust, thus BC is actually of smaller mass concentration than dust in the glacier/snowpack. Similar dust number concentration often means much higher mass concentration than BC; that is also why previous reports find more dust than BC in Tibet when compare mass concentration (Ming et al., 2008 ACP; Zhang et al, 2018 TC).

Moreover, in this study we mainly focus on individual LAPs particle mixing and structural change and its radiative forcing, thus we mainly use TEM-EDX method to calculate number concentration of the individual particle in the microscope observation. BC, OC, and dust mass data for the albedo simulation is derived from the average value of the previous study in the region (Zhang et al., 2017, 2018; Yan et al., 2016; and also Wang et al., 2013) for the snowpack result the northern Tibetan Plateau and also Qilian Mountains. See revised L170-171: In the model simulation, mineral dust (93.2 ± 27.05 μg/g), BC (1517 ± 626 μg/kg) and OC ($974\pm197\mu$g/kg) average concentration data, as well as other parameters...

References are also added to the revised manuscript: Ming J., Cachier H., Xiao C., et al., 2008. Black carbon record based on a shallow Himalayan ice core and its climatic implications, Atmos. Chem. Phys., 8, 1343–1352; Wang, X., Doherty, S., and Huang, J.: Black carbon and other light-absorbing impurities in snow across Northern China, J. Geophys. Res. Atmos., 118, 1471–1492, https://doi.org/10.1029/2012JD018291, 2013.

Minor Comments:

Line 43. "various salts . . . cause enhanced surface heat absorption". Which salts do you mean? Most salts are non-absorptive at UV, visible, and near-infrared wavelengths.

Author response: Yes, you are right, here we delete the salts, as salts in the atmosphere mainly influence the radiative forcing through salt-coating to BC/OC/dust, and also its hygroscopicity, which actually decreases the heat absorption (Li et al., 2014; Dong et al., 2017). See Line 46 in the revised manuscript.

Line 51. Delete “et al”

Author response: Yes, we deleted. Should be (Qiu, 2008)

Line 54. Anesio et al 2009 is missing from the reference list. Kaspari et al 2011 is also missing.

Author response: yes, we have added the references to the reference list in the revision. Anesio, A.M., Hodson, A.J., Fritz, A., et al., 2009. High microbial activity on glaciers: importance to the global carbon cycle. Global Change Biol. 15, 955-960. doi: 10.1111/j.1365-2486.2008.01758.x. Kaspari, S.D., Schwikowski, M., Gysel, M., et al., 2011. Recent increase in black carbon concentrations from a Mt. Everest ice core spanning 1860-2000 AD. Geophys. Res. Lett. 38, L04703 (2011).

Line 55. Xu et al. is missing from the reference list.

Author response: yes, we have added the reference to the reference list: Xu, B., et al. 2009. Black soot and the survival of Tibetan glaciers, Proc. Natl. Acad. Sci. U.S.A., 106(52), 22,114–22,118, doi:10.1073/pnas.0910444106.

Line 61. McConnell et al. 2007 is missing from the reference list.

Author response: yes, we revised, delete the reference here.

Line 74. Define TSP.

Author response: yes, revised, total suspended particle (TSP).

Line 105. Semeniuk et al. 2014 is missing from the reference list.

Author response: yes, revised: Semeniuk, T.A., Bruintjes, R.T., Salazar, V., Breed, D.W., Jensen, T.L., Buseck, P.R., 2014. Individual aerosol particles in ambient and updraft conditions below convective cloud bases in the Oman mountain region. J. Geophys. Res. Atmos. 119, http://dx.doi.org/ 10.1002/2013JD021165.

Line 120. Please give the values of MD, BC, OC for each individual glacier. Put them in Table 1.

Author response: Thank you for the suggestion, we have provided the general average mass concentration of BC, OC, dust of snowpack and glaciers in the region as shown in the method section. Besides, the number concentration to the mineral dust, BC and OC based on TEM-EDX measurement has also been shown in Figure 3.

Line 169. "Previous work". Give a reference.

Author response: yes, revised, we add the reference here of (Peng et al., 2016; Yan et al., 2016). See revised Line 251.

Table 1. The altitude for DF is given as 390 m. Probably you mean 3900 m.

Author response: yes, it is a mistake and revised. See Table 1.

Table 1. Add three more columns, giving the concentrations of BC, OC, MD in the surface snow of each glacier.

Author response: we appreciate your suggestion; we have provided the general average mass concentration of BC, OC, dust of snowpack and glaciers in the region as shown in the method section. Besides, the number concentration to the mineral dust, BC and OC based on TEM-EDX measurement has also been shown in Figure 3.

Line 398 (Figure 2 caption) "nitrates". The legends in Figures 2 and 6 say nitrite not nitrate.

Author response: yes, we revised the Figures 2, 3 and 6. Here it should be nitrates in this work.

Line 400 (Figure 3 caption). "snow and ice". Which of the ten sites were snow; which sites were ice?

Author response: yes, we revised. It should be the glacier and snowpack surface here, not exactly ice. We have described in the sampling section about glaciers and snowpack for the surface distributed impurities sampling. Here we revise to: Comparison of individual particles' compositions of light-absorbing impurities in the (a) atmosphere and (b) glacier and snowpack surface in the northeast Tibetan Plateau...(See revised Figure 3 caption in Line 518.)

Line 414 (Figure 8 caption) "mineral dust particles". No particles in Figure 8 are labeled as mineral dust.

Author response: yes, we revised. We delete the "mineral dust particles" in the caption.

Figure 2. Labels on the scale bars are illegible. Increase the font size.

Author response: yes, we revised to make it clear now. See revised Figure 2.

Figure 10. The vertical axes for the three graphs should all use the same scale, for easy comparison by the reader. Author response: yes, we revised. See the revised Figure 10.

Figure 10 legend. change "Mixted" to "Mixed".

Author response: yes, we revised.

Figure 12. The listed values for broadband albedo have too many significant figures. For example change "0.29774863" to "0.30".

Author response: yes, we revised. See revised Figure 11, as we change the order of Figure 11 and 12 based on the other review comments.

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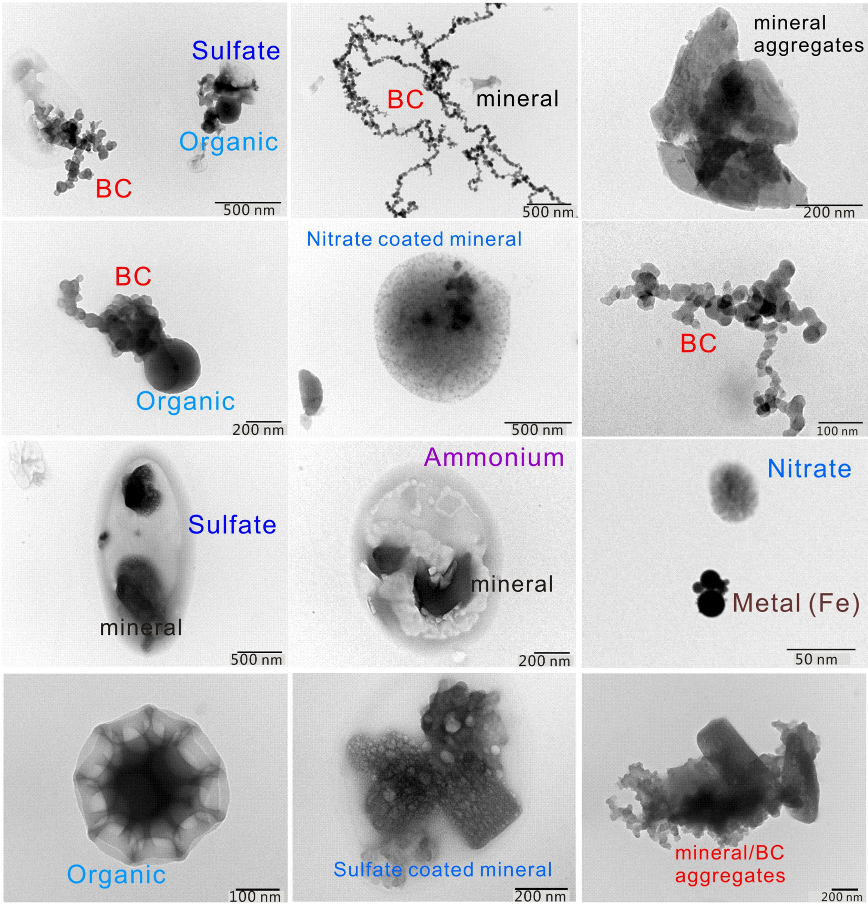

Fig. 1. revised Figure 2

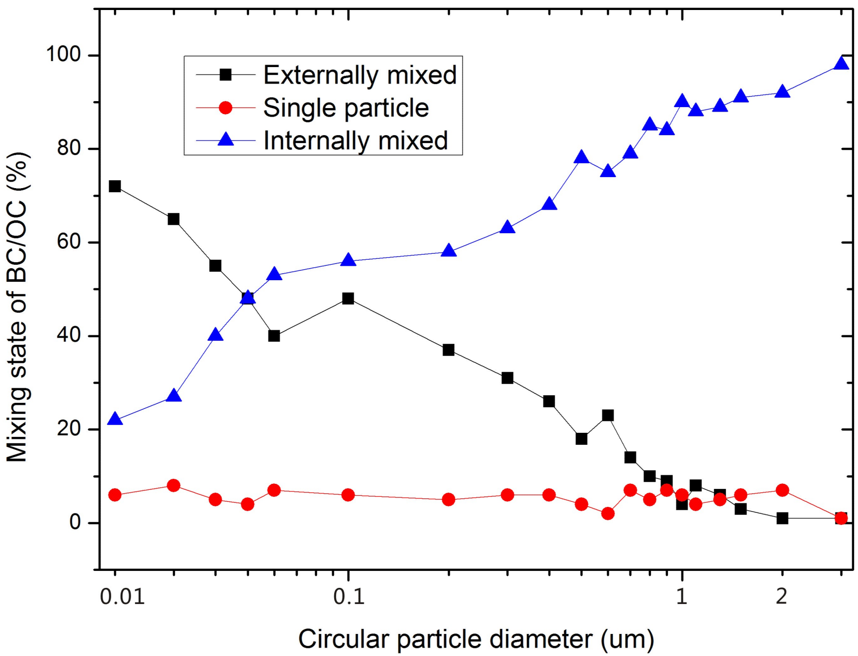

Fig. 2. revised Figure 10

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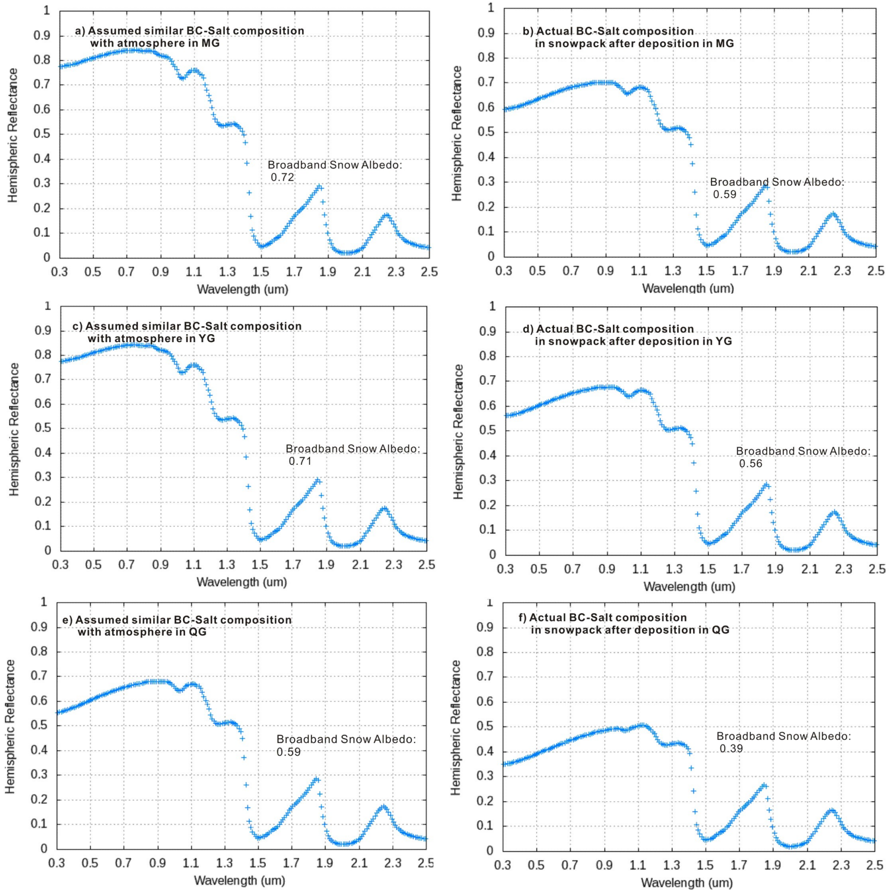

Fig. 3. revised Figure 11

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